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INDIVIDUAL STUDY PROGRAM

THE SELECTION AND DESIGN OF OPTIMUM COMBAT WEAPON SYSTEMS FOR NAVAL SHIPS

STUDY PROJECT REPORT
PMC 74-2

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GS-14 DNC

FORT BELVOIR, VIRGINIA 22060

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THE SELECTION AND DESIGN OF OPTIMUM COMBAT WEAPON SYSTEMS FOR NAVAL SHIPS.

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Study Project Report.

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Class 74-2

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AB

EXECUTIVE SUMMARY

This study report presents a management approach for developing a methodology for the determination and subsequent acquisition of the optimum combat system for Naval ships. Goal is to perform ship concept design and system development in parallel.

The current practice used by the Navy in planning advanced ships prevents the Navy from producing a truly cost-effective ship. The resultant advanced ship is often not optimized to perform its required military mission, since at early stages of its planning, key ship parameters including cost, often arbitrarily selected, become firm and frozen. The advanced ship program, in particular, with their over-emphasis on the hull and propulsion, at the expense of the combat system, tend to lead to new ship designs having insufficient military utility.

The present nature of the advanced ship planning process tends to lead to combat systems that do not necessarily take advantage or account of the unique ship characteristics, and this in turn fails to optimize the ship's military benefit. OSD and Congressional reviewing authorities tend to find such programs difficult to approve since their potential advantage over existing concepts are not fully developed and supported.

The planning process can be greatly improved by organizing a balanced team of ship planners, naval architects, weapon system engineers and operations research analysts to conduct mission analysis and ship concept design. The combat systems of the advanced ship should be developed in parallel with the ship's RDT&E at the early concept design phase. The selection of weapons and sensors and design of an optimum combat system

should be based on mission analysis, rather than arbitrary selection by Ship Characteristics Boards or Committees.

The management approach proposed is to present the means of establishing within the Naval Material Command an effective organization, responsive to the CNO established configuration and design requirements for new ship construction and conversions.

ACKNOWLEDGEMENTS

I wish to convey my sincere appreciation to Captain Walton T. Boyer, Jr., USN, and Mr. Ronald E. Adler, my current working associates in NAVSEA (SEA-6512), who both have contributed many hours of discussion on my selected study topic.

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THE SELECTION AND DESIGN OF OPTIMUM COMBAT WEAPON SYSTEMS FOR NAVAL SHIPS

SECTION I

INTRODUCTION

1.1. Purpose

The purpose of this study is to present a plan for organizing and establishing a qualified professional organization within the Naval Material Command (NMC) Headquarters that is responsive to the CNO's new construction and shipbuilding objective by developing ship and combat weapon system designs that fully meet the mission needs of the CNO. It would be presumptuous to state that the approach outlined in this study will solve the Navy's problem of determination and selection of the optimum combat weapon systems for surface ships. This study will attempt to outline an improved method by addressing the following major issue: "How do we determine the most effective combat weapon system at lowest cost and most suited to the ship's missions?"

OBJECTIVE: The selection and design of optimum combat systems for naval ships is the key issue of this report. Optimum is defined here as the greatest degree (maximum military effectiveness to perform desired ship missions) attached under specified conditions (lowest relative cost to ship and acceptable levels of technical risk).

The increasing strength of the Soviet Navy and the worldwide projection of its power have caused our Navy planners to press for a revitalized U. S. Navy. The growth in capability and numbers of the anti-ship cruise missile and the nuclear attack submarine plus the coordinated, multi-platform attack represents the most dominant challenge to U. S.

Naval supremacy. As new weapon systems and their platforms, capable of coping with the threat, are devised, their complexity - demanded by the nature of the threat - leads to very high cost.

The variety of U. S. developed, shipboard weapon systems, both offensive and defensive type, is vast. In addition to our own U. S. developments, friendly foreign nations have produced or have in R&D a sizable arsenal of new system alternatives. Consequently, U. S. Navy planners are confronted with the difficult process of selecting the proper weapon systems or combat system for new ships and those being modernized. They realize that this selection process is complicated by the large set of available options and by the uncertainties in performance as well as ultimate costs of these options. The questions facing the decision maker who must select among the wide range of options are: How effective is each particular system, and how effective are the various overall ship's combat systems (suite) composed perhaps of several distinct weapon systems? To attain solutions to these questions requires the use of suitable analytical techniques.

1.2. Scope

This study discusses the reasons why significantly improved analytical methods are vital in assessing combat capability during the design process. Our objective clearly must be achievement of maximum mission effectiveness in these present and foreseeable times of reduced ship numbers resulting from increased costs, and in light of ever-developing ship system complexities.

1.3. Conduct of Study

This study was conducted between August and October 1974, concurrent

with my attendance at the DOD Defense Systems Management School (DSMS), and involved a limited but comprehensive survey of key literature on Naval Weapon Selection and Design for New Warship Construction or Modernization. Information was obtained from personal interviews with key personnel who have either submitted papers on the subject to Technical Journals or have been intimately involved in the analysis and preparation of specific combatant ship studies (5:33-39; 6:28-53; 11:56-66).[1]

1.4. Glossary and Selected Study

For purposes of this study, Glossary and Selected Study are explained in Appendices 1 and 2, respectively.

1.5. Organization of the Report

This study report is divided into Section I - Introduction and Objectives, Section II - Current Approaches of Tactical Combat System Selection - addresses the adequacy of the Navy's current method; Section III - Problems of Current Approaches and procedures in use by the Navy; Section IV - Research Study Results and Findings based upon data collected through interviews, analysis of technical journal findings which then discusses the outcome of the search and notes relevancy and differences; Section V - Other Findings - discusses organizational problems within the Naval Material Command and a possible solution; Section VI - Conclusions and Recommendations is based upon the findings reached in Sections IV and V that led to my final recommendations.

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[1] This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The number following the colon, if any, is the page in the reference.

SECTION II

CURRENT APPROACHES

2.1. Discussion

The pace of shipbuilding in the Navy has greatly expanded over the past nine years. The Navy has a considerable investment in its shipbuilding program, not only in the billions of dollars needed to finance it, but also in the future military capability of the Navy. Consequently, it is vital that the best possible ships, equipped with the most effective combat systems, are designed and produced t the lowest possible cost. Even since mid-1970, several new ship classes have been designed and are now in various stages of design or construction. The Sea Control Ship, Patrol Frigate, Patrol Hydrofoil, and the DG are SCN programs; while newer ship concepts, like the SES and Advance Hydrofoils, are R&D projects in advance development.

The process of Naval Ship concept design and determining characteristics has varied considerably from class to class. Earlier ships were always designed by BUSHIPS having full detailed characteristics furnished by the former Ship Characteristics Board.

Later, a trend toward Concept Formulation/Contract Definition (CF/CD) was attempted in which a private shipbuilding contractor would design a ship after the Navy had completed its formal Concept Formulation to establish the overall ship characteristics.

The Navy has now the opportunity to adopt a better procedure that has the potential to utilize the best features of many of the former procedures while avoiding their well-known shortfalls and failures. This

paper examines a new management approach which can best achieve the goal of designing combat effective ships constructed at low costs.

2.2. Ship Characteristics Determination (9)

Ship Characteristics used to be developed in the Ship Characteristics Board (SCB) in which professional expertise of OPNAV and the NMC were continually and responsibly represented. (See Figure 1 - Pre-1965 Design Sequence.) Beginning with the introduction of the CF/CD process in 1965, the continuous, responsible representation of the NMC in the development of Ship Characteristics has deteriorated. The Ship Acquisition and Improvement Council (SAIC) was established 22 September 1970, replacing the Ship Characteristics Board. The SAIC is assigned cognizance for developing, monitoring and controlling the characteristics of all ships, floating dry-docks, landing and service craft and YTB's, YTM's and YP's. The basic approach used in deriving characteristics for new ship construction and ship conversion is through formal and informal working groups, under the sponsorship of OPNAV Ship Program Coordinators, and under the guidance and review by the SAIC. The SAIC organization and membership are identified in OPNAV Instruction 5420.31D of 25 May 1971.

2.3. New Ship TLR/TLS Development (1974) (10)

Historically, OPNAV has imposed its new ship requirements of NAVMAT in the form of Ship Characteristics. For each ship these characteristics have been restricted to a small number of important features and to equipment lists usually aimed more at budget determination rather than for adequate description of what the Fleet should expect to receive in terms of ship combatant capability performance in the actual environment. Yet Ship Characteristics form the only "contract" between NAVMAT and OPNAV for

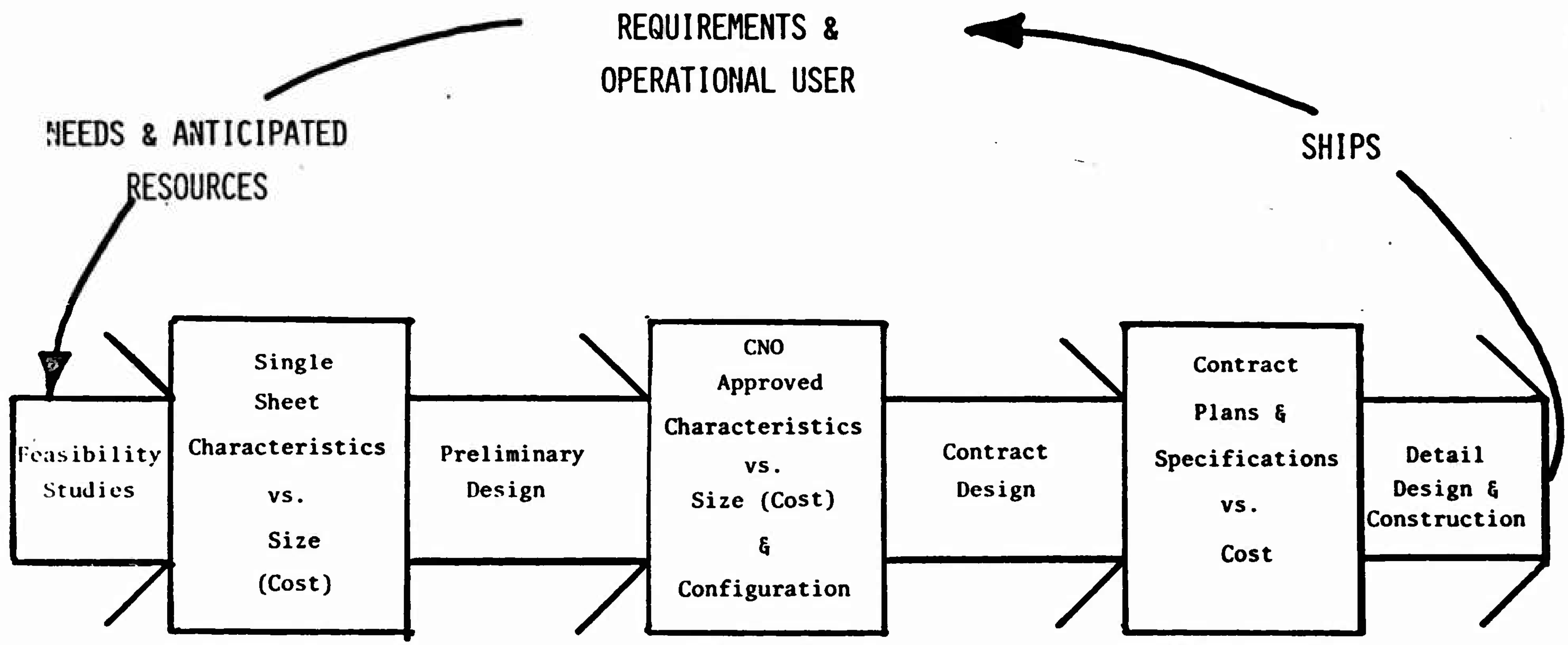

FIGURE 1 - PRE-1965 DESIGN SEQUENCE

a specific ship. To cover some unspecified areas, statements such as "best available" or "state of the art" have been prevalent in the characteristics. However, in large measure there has been dependence on current practice to deliver a ship that meets Fleet needs. Occasionally this "current practice" is approved for all ships by OPNAV in areas such as Habitability Standards.

"Current practice" is not enough since severe budget constraints are driving PF and with accelerating technology driving PHM and SES. OPNAV and NAVMAT need to work together to improve greatly the definition of what is required in performance terms. Under OPNAV Instruction 9010.300 of 4 January 1974, the effort has been made to produce the "Top Level Requirements and Top Level Specifications for the Development of Naval Ships" (TLR/TLS).

This most recent CNO directive has, for purposes of this report, a few points that are particularly applicable. Expanding on the need for change, but not dismissing the values of past practice, is the following: "There was little formal documentation available to OPNAV of the effort expended to maximize a ship's mission effectiveness related to Navy Force needs while at the same time minimizing ship costs. As a result of this unstructured approach, ship definition had not kept pace with the realities of declining force levels, the present fiscal climate and the changing acquisition processes."

The objective of the Top Level Specification is to describe the total ship system in terms of minimum acceptable performance, near-term logistic requirements and major design constraints. The purpose of the TLS is to define the mutual agreement between the user command (OPNAV) and the producer command (NAVMAT) for the total ship system vice the current utilization of "approved characteristics" and "equipment lists" in the ship concept

and development process. The TLR/TLS would be structured around the military missions and tasks for a particular ship class as approved by the CNO.

A secondary purpose of the TLR/TLS would be to provide more positive guidance from NAVMAT to the design activities with the intent of reducing the quantity of future change orders.

Figure 2 diagrams the key steps in the design process as required by OPNAV Instruction 9010.300. It can be readily seen that familiar phases of Figure 1, "Pre-1965 Design Sequence" are not displaced, but, rather, augmented to meet the new requirements discussed earlier.

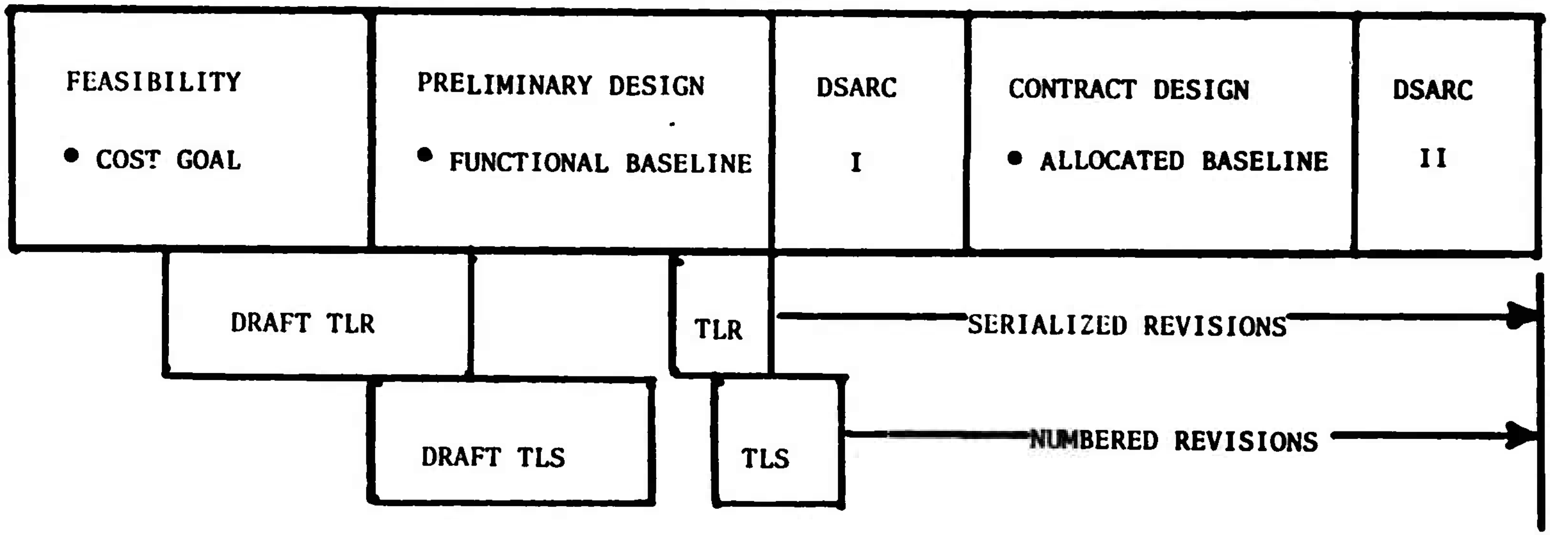

FIGURE 2 - CURRENT DESIGN SEQUENCE (TLR/TLS)

SECTION III

PROBLEMS OF CURRENT APPROACHES

3.1. The Overall Problem (3)

A concrete basis for logically selecting the total ship design features has not been uniformly implemented. The present Navy planning procedure is not well suited for successful development of non-conventional, advanced naval ships.

The following problems are symptomatic of current ship characteristics development:

- There is no NAVMAT implementing guidance causing non-uniformity and some confusion.
- Multiple concurrent OPNAV-established ship study groups dilute NMC resources.
- There is no continuity in the OPNAV-established study groups causing repeated studies of the same questions and neglect of others.
- In conceptualizing the new ship, OPNAV provides arbitrary equipment lists rather than mission and/or performance-oriented characteristics, which reduce ship design flexibility. This also restricts design options and achievement of highest military effectiveness at lowest cost.
- The working group approach may not consider total ship impact in that all responsible technical and operational disciplines are frequently not represented.

- Arbitrary equipment-oriented, rather than mission and/or performance-oriented, decisions reduce design flexibility. Restricts design options and achievement of highest military effectiveness at lowest cost. (Too many design decisions made at top level.)
- Conflict of CNM authority vs. CNM responsibility. Critical design issues do not receive CNM visibility and approval. Designation of ship characteristics without full assessment of ship trade-off, military effectiveness, detailed costs, and full disclosure of risks.

3.2. Discussion (3)

Prior to January 1974, the pre-TLR/TLS approach for new ship acquisition and ship conversion was based upon OPNAV Instruction 5420.31D dated 25 May 1971 (9), which established the Ship Acquisition and Improvement Council (SAIC) as the successor to the SCB. The SAIC was made responsible for "developing, monitoring and controlling the characteristics of all ships, floating drydocks, landing and service craft and YTB's, YTM's and YP's." The SAIC was empowered to develop and recommend to the CNO, ship procurement plans, and specific ship characteristics for new construction, conversion, and modernization and improvement programs." Additionally, "to review and monitor for the CNO the progress of all ship acquisition programs. The developed plans and characteristics must consider the criteria of military worth, technical feasibility and financial acceptability."

The OPNAV Instruction also established implementing procedures; however, the Instruction was not being uniformly implemented with OPNAV.

For example, OPNAV-directed working groups could be formed under this Instruction throughout the Navy Department. These ad-hoc study groups would "do the research, monitor R&D program progress, weigh trade-off analyses, conduct working level meetings to develop the detailed characteristics of each ship type to be considered by the SAIC."

The success of the ad-hoc study groups was heavily dependent upon participation of NAVMAT personnel, since it was primarily in NAVMAT that the requisite expertise was found. This NAVMAT expertise was in the area of weapon system performance, examining alternative configurations, ship's combat suite effectiveness, ship performance and design in hull and propulsion, and overall cost estimating. In the past, OPNAV study group operations have not been successful in producing a satisfactory product. For example, OPNAV study groups, employed for determining the characteristics of the PF utilized NAVORD, NAVSHIPS, PM-4 and NAVSEC personnel ineffectively. The guidance these members were given was frequently contradictory, and some arbitrary decisions prevented good alternative systems from being considered in the trade-offs. Systems were ruled out presumably on the basis of high cost, even before costs were actually determined for the systems or the total ship. Other arbitrary constraints on details of ship design were made which greatly restricted overall ship design options. Some constraints were unrealistic, such as imposing a maximum displacement, while at the same time imposing detailed characteristics and design criteria that would exceed the allowable displacement.

A continuous stream of assignments to NAVMAT personnel for reworking the trade-offs and ships designs were made without providing official mission goals or scenarios. Consequently, these operations became needlessly

protracted, extending over a considerable length of time, often preventing many NAVMAT personnel from carrying out their required NAVMAT tasks and assignments. Guidance in the ships missions was often confusing. Often when an arbitrary preselection system might be shown by analysis to be less effective than a lower cost candidate, the better, lower cost candidate was often ordered to be dropped from further consideration. Even the mission of the ship might be changed to better justify the use of a preselected hardware subsystem. Frequently, the concept of total-ship effectiveness was ignored in the trade-offs presented to the decision-maker in favor of system of subsystem effectiveness. Trade-off studies and ship design alternatives were not usually documented into report format for review and justification to higher authority such as DDR&E or Congress. Pressure was frequently exerted toward minimizing essential cost elements which tended to underestimate the true cost of systems, systems engineering, or ILS support in order to keep the total-ship cost below a pre-established cost limit. The individual members of the OPNAV study group, because of the short response times and the informality of the study group required by an OPNAV sponsor, often could provide only fragmentary visibility to their parent commands of their technical inputs.

Finally, this procedure provided for essentially no visibility as to ship design characteristics to the CNM himself or his Shipbuilding Council until well after the characteristics of the ship were selected. These ship characteristics will ultimately determine the military capability and effectiveness of a new ship to be built by NAVMAT, and for which the CNM will have considerable responsibility; yet by this procedure, effective official participation at high levels and by the CNM himself was not possible.

The NMC has already proven it can produce integrated combat system and ship design alternatives using analytical techniques of the Concept Formulation process for new ships. Examples of NAVMAT participation are: the CVAN-71, LFS, DLGN-25 ASMD modernization, PHM, PF, Sea Control Ship, DG ship design study, the DD-963 Point Defense Modernization, and most recently the Deepwater Escort Hydrofoil (DEH) Study. These products in the form of trade-off analysis of combat suites, ship design alternatives, risk assessment and cost estimates were certainly not as complete and well done as they could have been owing to a combination of reasons. They were either inadequate guidance from OPNAV on ship missions and scenarios, or inadequate management and coordination by NAVMAT of the NAVMAT analytical effort.

3.3. Prior NMC Studies

In spite of a few valid criticisms cited by OPNAV, the NMC has participated with and supplied data to OP-36, OP-96 and others, and has conducted complete trade-off studies in support of ship characteristics decisions. Recently, NMC has been so involved in DLGN-25 ASMD effectiveness, PHM suite selection, AS and AD self-defense, DD-963 updated self-defense and others. These studies were based on the OPNAV mission requirements and investigated alternative complete combat systems, costed these systems, and recommended the most cost-effective systems to OPNAV. The actual shortcoming of many NMC-assigned tasks lies in the inability of OPNAV to identify the ship performance requirements, time or cost constraints, or even the operational missions, scenarios or threat requirements for the ship.

Supplying correct data to an analysis group is only one part of the task of investigating combat systems, where the equipments must work

together and the total system be capable of performing the military function. Analysis cannot be performed, removed from either the operators or the equipment engineers. This systems engineering analysis of fully integrated combat systems can be, as performed in the NMC in response to the CNO needs, the only logical approach. Secondly, costing of candidates is best done by the NMC with contractor support.

A typical example of the type of total support provided by NMC is the previous "DG ship design" performed jointly by SHIPS-SEC-ORD and others in the NMC. This integrated study involved developing a complete ship around a modified AEGIS Weapons System, the necessary sensors, command and control, and the personnel required.

Listed below are the Ship Weapon System and Integrated Combat Suit Studies performed by the Ship Characteristics and Weapon Systems Analysis Division of the Naval Ordnance Systems Command (ORD-531) now known as the Combat Systems Analysis Division (SEA-6512) under the new Naval Sea Systems Command effective 1 July 1974 (8).

A representative listing of these prior studies conducted during the period 1970-1973 includes:

	TITLE	BRIEF	SPONSOR
A.	CVAN-71 Concept Formulation Study, Evaluation of Potential Defensive Weapon Suites.	Selection of candidate weapon systems, combining them into defensive suites, evaluating their firepower capabilities against postulated threats, analyzing their impact on ship design with respect to space/weight/location/ship services, and determining life cycle costs.	NAVSHIPS (PMS-392)
B.	Evaluation of the ASMD Improvements for the DLGN-25	Evaluation of the cost versus performance of 13 proposed AAW/ASMD improvements for the DLG classes of ships.	NAVSHIPS (PMS-378)
C.	NAVORD Concept Formulation for Amphibious Fire Support Ship (LFS).	Extensive analyses of the potential ordnance suits for the Amphibious Fire Support Ship (LFS).	NAVSHIPS (PMS-378)
D.	Self-Defense Armament for Attack Submarine Tenders and Destroyer Tenders.	Analyses of nine alternative self-defense weapons suites for the AS and ten suites for the AD. Studies included analysis of mission requirements, concepts of war-time operations, performance, costs, and shipboard mechanical requirements.	NAVSHIPS (PMS-383)
E.	Defensive Equipping of Merchant Ships (DEMS).	A cursory analysis of effectiveness against assumed threats and estimated magnitude of investment costs of a representative sample of defensive weapon systems.	NAVORD (ORD-011)

ORD-531 SHIP COMBAT SUIT STUDIES (1970-73)

	TITLE	BRIEF	SPONSOR
F.	A cursory evaluation of Sea Control Ship (SCS) Self-Defense System Suites.	A NAVORD evaluation of several candidate AAW, ASW, and SUW self-defense suites for the SCS in response to an OP-96 request.	PM-15 PMS-397
G.	DD-963 Point Defense Suite Evaluation Study.	A study of alternative point defense weapon systems for possible installation in the DD-963 class ships, including evaluations of relative effectiveness, risk factors, performance limitations and increase in cost over the baseline DD-963 configuration.	NAVORD (ORD-05)
H.	DG Ship Design Study.	A study to determine the feasibility and best ship variant, a low cost DG that is optimized for AAW area protection, surface warfare, and ASW self-defense. Study included a comparison of cost and effectiveness of DG variants to baseline ships.	NAVORD (PMO-403) (ORD-05)
I.	Surface Effect Ship (SES) Weapon System Confirmation Study.	Evaluation of candidate weapon systems for AAW, ASW and SUW missions for the 220 Ton SES.	NAVMAT (PM-17) NAVORD (ORD-05)
J.	Evaluation of Candidate Weapon Systems for Patrol Hydrofoil Guided Missile Ship (PHM).	Detailed analysis of candidate weapon systems for the selection of a primary surface-to-surface missile (SSM) system; and the selection of a weapon system(s) to be used for self-defense and to complement the primary offensive SSM.	NAVSHIPS (PMS-391)

ORD-531 SHIP COMBAT SUIT STUDIES (CONT'D)

3.4. Observations

As the NAVORD single point-of-contact for ship characteristic matters, ORD-53 has fully recognized the need for a more responsive organization within the NMC which can better fulfill the CNO's new construction and shipbuilding objectives by developing ship and combat system designs that fully meet the mission goals of the CNO. The prior guidance from the CNO (OPNAV Instruction 5420.31D) provided for the establishment of "working groups," under the direction of an OPNAV ship class project officer, to develop recommendations of ship characteristics for consideration and decision by the formal Ship Acquisition and Improvement Council (SAIC) (9). These procedures were not routinely followed by OPNAV in the determination of recent new construction ship characteristics. A concrete basis for logically selecting the total ship design features has not been uniformly implemented which further validates the need for a new approach discussed in Section V.

NAVSEC was assigned by NAVSHIPS the task of developing a Ship System Specification (Top Level Specification) outline based on performance requirements which would serve as a guide for developing detailed requirements for specific ships. A "Steering Panel," consisting mainly of NAVSEC personnel with invited participation from NAVORD, NAVELEX, and NAVAIR, was established to monitor and approve the concept and the contents of the TLS after it was developed by a NAVSEC working group. The Patrol Frigate (PF) was selected as the sample procurement for which to develop the TLS. Although the TLS for the PF provided an "initial look" at the solution to this problem, the ultimate TLS design package was far from complete. In addition to the currently emphasized "total system performance," the TLS must give equal importance towards the requirement that "total system effectiveness" will

also "drive" the ultimate selection of ship characteristics (10).

There is a definite need for a closer bond between OPNAV and NAVMAT in the final determination of new ship designs. This bond must recognize the "good faith" intentions of the other, i.e., the final TLS product must be recognized as a legitimate document in support of the characteristics determination and not just another "paperwork exercise." Full support of the TLS concept at the highest CNO levels should be enforced during its implementation within NAVMAT. The TLS tends to restrict the OPNAV decision-maker to the single match of characteristics-to-mission requirements. There are, for example, many reasons why the CNO would wish to change or modify characteristics. These reasons are risks, costs, schedule changes, T&E results, etc. Consequently, the TLS would be continually out-of-date because of changes. What the CNO really needs rather than a TLS document as a "contract" is a continuous updating on alternative systems and sub-systems regarding their effectiveness, costs and risks, such that he can make needed changes as they arise.

3.5. Conclusions

As evidenced by the above comments, a need clearly exists for the implementation of new procedures which will provide a more effective bond between OPNAV and NAVMAT in the determination of ship characteristics which will meet the Fleet needs. It is my opinion that the TLS is not a practical solution to this problem.

SECTION IV

RESEARCH STUDY RESULTS AND FINDINGS

4.1. Discussion (2:81-87)

New analytical techniques have evolved in the past few years that could help in this difficult and important selection process. The planning procedures to be described may seem obvious, but their proper practice has too often been limited by one or more of the following factors: fear that comprehensive study would be too complex; arbitrary preselection of certain systems preventing examination of the full range of options; limitations of time, resources or necessary expertise.

The preferred process should rightfully start with the definitions of force requirements, namely, "approximately how many of which types of notional ships are needed by the U. S. Navy to carry out its military missions and goals on a worldwide basis?" It is in these force studies that the true additional contribution of new and innovative concepts to contributions already available from existing concepts can be examined. These mixes of existing and new systems could include such concepts as new high speed ship platforms (surface effect ships, hydrofoils), airborne adjuncts to ships (AEW helos sea control ship), remote sensors, and surface and ASW surveillance techniques. These force studies should be used to produce gross estimates, i.e., relative indicators of numbers, types and capabilities of platforms needed. This approximation approach is preferred to the more detailed force level studies which, because of their complexity, have too often in the past produced confused and unhelpful results even when done according to the accepted practices.

From gross estimate force studies, however, the Navy should be able to identify its general deficiencies in types and approximate numbers of notional ships. Once we have defined the mixes of ships we will need, our next step is to define each ship's mission. An adequate mission description should incorporate the specific tasks the ship must perform, performance goals and likely threats based on intelligence projections. Submarine, surface and air threat types in various tactical situations and environments are preferred over the use of only one or two typical threat types to prevent a "point solution." The likelihood of occurrence of the various threats and environments or the priority of individual missions out of a set of multiple missions should be established for correct ordering of study results.

Next, weapon system candidate lists should be broadly defined according to their suitability to a notional ship's mission. The weapon system candidates are then combined into suites along with supporting sensor and control subsystems. They are next laid out on a baseline ship to validate mechanical feasibility and to maximize firepower. At this point in the study it is wise to expand the list of candidate weapon systems to form two distinct categories, namely, those systems that have already passed their operational test and evaluation and those in earlier stages of development that would be appropriate for subsequent follow-on ships of the class. Planning and costing for the installation and integration of these advanced systems should be done continuously, starting at the earliest stages of ship design and updated as required since this planning, if deferred, makes the later transition far more difficult. This approach helps avoid the costly trap of block obsolescence of an entire ship class.

When candidate systems are combined into complete weapon suites or combat systems, trade-off analyses should be conducted of the "total ship" combat system to determine how adequately each performs the ship's mission. Intimate knowledge of system performance and input parameters is essential to a meaningful analysis. All important modes of system operation should be examined. The interaction of all subsystems with the ship's command and control should be varied to maximize "total ship" effectiveness in terms of defeating the various threats. The tradeoff study must be designed to produce an output of weapon suite effectiveness always measured in terms of the mission goals of the ship. Often, several iterations of weapon suite effectiveness are needed during the study as changes in suite configuration are made and as preliminary results become available.

The decision maker must then weigh the effectiveness of various weapon suite alternatives with their cost as well as with total ship cost. Risk assessment also plays a part in the weapon suite selection process. Critical risk issues for a specific system must be presented. Whenever risk introduces uncertainties, removal of the risk through additional testing, analysis and review would allow for retrofit in later follow-on ships. Systems should not, as in the past, be added to the ship's combat system unless they can be shown to add directly or indirectly to effectiveness.

For the various reasons described earlier, the Navy has never really exploited the full range of procedures. However, when properly practiced and applied, these procedures and techniques can become powerful tools useful in selecting the best weapon suites for ships.

4.2. Ship Concept Design and Mission Analysis (1:67-78)

A properly conducted analysis of the overall advanced ship along with

an analysis of its combat system will produce the desired result, i.e., total-ship concept formulation. A proper analysis would lead to a set of subsystem developments that should fit together into an integrated ship's combat system. If the advanced ship's combat system needs to be a multi-mission suite, then the ship study approach is the only possible means of establishing meaningful development requirements. This is true because the multi-mission ship, having such combined missions as ASW, AAW, EW and SUW, will have to utilize weapons and sensors whose capabilities are interrelated through an optimum concept of operations. During the course of the analysis, numerous trade-offs can be made between various mission equipments. Also, trade-offs can be made between the combat system and certain of the advanced ship characteristics. Even design-to-cost ship and combat systems can be handled by these methods where target costs or cost levels can be set. Trade-offs can be made to keep the total-ship cost within the desired limits.

One important aspect of any successful study is its management. To make the analysis work, the study team management should include the best talent the Navy can muster, both from in-house and industry sources. The study should be properly funded, constituted for sufficient time to do the job and vested with necessary objectivity and authority to penetrate the complex hierarchy within OPNAV and NAVMAT.

The team should be a grouping of these skills: ship planners, naval architects, weapon system designers, weapon system analysts, and operations analysts. The study team should not be dominated by overemphasis on any one of the above skills. The leader of the study team must be firm but equitable and always keep his sights set on the ship's mission objectives and its eventual military-worth justification.

Eleven Commandments of Naval Planners, Designers and Analysts

1. Allow sufficient time.

2. Centralize direction and responsibility.

3. Relate scenarios and threats to overall Navy planning.

4. Define and adhere to mission goals.

5. Examine full range of system alternatives.

6. Base effectiveness measures on ship missions.

7. Rank basis of relative effectiveness.

8. Include qualitative (judgment) factors.

9. Present risks and uncertainties with effectiveness.

10. Compare systems using a common cost model.

11. Obtain decision maker participation throughout.

4.3. Deepwater Escort Hydrofoil (DEH) Study (7)

One successful study effort recently completed was the Mission Analysis and Ship Concept Design of the Deepwater Escort Hydrofoil (DEH). In this mission study, the Advanced Ship Office of NAVSHIPS recognized the need to properly define the characteristics of the large fleet hydrofoil. That office sought to overcome the limitations of previous mission studies and requested NAVORD to conduct a total-ship concept formulation of the DEH. The resulting Naval Material Command project was a working-level team consisting of personnel from NAVORD, NAVSHIPS, NAVELEX, NAVSEC, NSRDC, plus a team of contractor analysts under NAVORD direction.

Several alternative ship designs and displacements were formulated using a baseline hydrofoil design. Also, several multi-mission combat system alternatives were defined, evaluated and compared. The combat systems were each tested for installation feasibility on the various

notional ships. Concepts of operations were devised for the DEH to exploit the principal performance advantages of a large hydrofoil. Total-ship cost and a risk analysis were also conducted. A full set of operational requirements for weapons and sensors could be prepared using the DEH study findings. (See DEH Study in Appendix 2.)

Finally, the DEH force mix was compared to the conventional ship force mix on the basis of military effectiveness and costs. Overall results of the DEH study indicated significant cost-effectiveness advantage for this advanced ship over the conventional ship escort.

4.4. Relevant Related Efforts

The greater part of the research and data collected for this study was obtained from articles appearing in the Naval Engineering Journal and information I have obtained through interviews or discussions with personnel in the Naval Material Command.

In the course of researching my subject, I discovered that there are numerous related efforts and approaches (past and present). Some of these addressed one aspect while others addressed several aspects of the problem and were considered relevant. However, none seems to address all aspects as covered in my approach (1-6 & 11).

4.5. Differences

As stated above, the material I located during my research appeared to address only limited aspects, mostly in the area of ship design, in the determination of the totally dedicated combat system. The approach I have taken in this study addresses much more than the design. It is "management" to produce the total system based upon mission oriented analysis. It is the effective analysis, qualitative factors, installation feasibility risks

and cost that form the proper basis for weapon suite selection.

4.6. Overall Findings

- Early stage of Advanced Ship Design typically finds:
  - Ship Weapon Characteristics arbitrarily selected.
  - Pro Forma Missions Analysis
  - Ship Cost ceiling set.
- Comparison to Alternatives is inadequate.
- Mission Analysis is vital at early stage of ship design to define combat system requirements.
- Trade-offs between Ship and Combat System must aim at highest military effectiveness at minimum cost.
- Military effectiveness is derived from combined use of combat system and tactics that exploit the ship's unique characteristics.
- Some key weapon/sensor systems will require development if advanced ships are to be useful and justified.
- Navy requirements and R&D organizations poorly structured for advanced combat system.
- Advanced ship and its combat system need parallel development and OT&E.
- Trend to higher cost fraction of total ship for combat system justified by sharply increasing threat.
- Effective, but moderate cost, ship possible using high performance combat system on low displacement hull.

SECTION V

OTHER FINDINGS

5.1. Proposed NMC Organization for New Ship Design and Conversion (3)

The Naval Material Command has, collectively, the necessary technical personnel available and, given adequate funding and leadership, can do an excellent job of defining a new ship or ship conversion capable of meeting the mission goals and other constraints stated by the CNO. Because new ship concept formulation and design required diverse skills derived from varied technical and analytical disciplines found in several of the Systems Commands, a means must be found within NMC to organize these talents into an effective and responsive team. Because such a team must give guidance, tasking and directions to several SYSCOMS and PM's, it should be managed from a high level within NAVMAT Headquarters. Full-time Flag level leadership is considered absolutely essential, not only to effectively mold together the somewhat diverse (often uncompromising) SYSCOM and PM membership, but also to represent the Chief of Naval Material and the CNM Shipbuilding Council to the Flag Officer SAIC or the individual OPNAV Ship Project coordinators, who are themselves Flag Officers.

What is needed therefore in NAVMAT is a new but small organization dedicated to the Concept Formulation design of all new ships or ship conversions. It should be headed by a Flag Officer and staffed by a group of selected officers and civilians who have already demonstrated their accomplishments in Ship Concept Formulation.

5.2. The Navy Preferred Approach

While it does not make much difference which OPNAV office directs

the ship characteristics, it is critical that the correct guidance be furnished to the NMC. The preferred approach for the Navy to follow is the one that best uses the talents and expertise wherever they are located.

The contribution that NMC can make is one where we continue to pursue the approach taken on some of our more recent trade-off analyses. This is where we, various SYSCOMS working together or perhaps even a new Combat Systems Command, can carry out the following steps:

1. Receive, review and use the missions and scenarios that OPNAV develops for a new ship or ship undergoing modernization.

2. Develop logical combat system alternatives that logically meet the stated ship's mission needs.

3. Analyze the total ship effectiveness for each alternative and present and document results.

4. Develop, refine and submit cost estimates for each alternative and present the cost along with effectiveness results to the OPNAV decision maker.

5. Since no study is complete without technical, cost and schedule risk assessment, the two should be done by the NMC where the knowledge of the hardware resides.

It is suggested that OPNAV continue to conduct the force sizing studies from which strategies, scenarios, threats are defined. Furthermore, OPNAV should endeavor to produce meaningful ship-mission descriptions that define the roles and tasks the ship is to perform. These mission descriptions in the past have been, in the majority of cases, very weak and, as such, resulted in poor definition of what the ship must be able to do.

5.3. Alternative Approaches

Several alternatives have been suggested, and most of them have been discussed briefly at a meeting of the NAVMAT Collocation Group having representation of the several SYSCOMS. These alternatives are listed below:

1. CNM Ship Design Executive (SDE) (MAT-0X) with full staff
2. CNM Ship Design Executive (SDE) (MAT-0X) with skeleton staff
3. SHAPM for individual ship is SDE.
4. Create Combat Systems Command and assign Commander as SDE.
5. Create ad-hoc groups in NAVMAT to support OPNAV as required.
6. Continue current practice of using informat ad-hoc groups under various OPNAV managers.
7. The so-called "Arlington Boatwerkes" permanent group.
8. Total OPNAV/NAVMAT reorganization aiming at integration of OPNAV and NAVMAT with reduction in layering.

Although not unanimous, the consensus was in favor of Alternative 2. This alternative is considered a low-overhead operation having limited size staff. It has the advantage of having the needed Flag Officer as its director, properly located in CNM, having close direct liaison with the CNM plus a qualified staff able to task (and monitor) the Systems Commands or PM(s) to conduct necessary analysis and ship design alternatives. Unlike Alternative 1, this smaller organization does not have the problem of excess staffing should the tempo of ship projects taper off. Alternative 8, total OPNAV/NAVMAT reorganization, seems not too far in the future and might offer the ultimate solution to this immediate problem. It is therefore not dropped from further consideration.

ALTERNATIVE 2

CNM SHIP DESIGN EXECUTIVE, MAT-OX (NOT PM)

- Headed by flag rank officer.
- Small staff in CNM.
- Provides new class ship design planning interfaces with OPNAV.
- Tasks SYSCOMS to perform Concept Formulation Trade-Off Studies based on CNO-supplied mission goals, including threats and scenarios and constraints.
  - a. Develop combat suite alternatives.
  - b. Analyze total-ship effectiveness of alternatives.
  - c. Develop ship performance objectives.
  - d. Estimate costs.
  - e. Provide risk assessments.
  - f. Publish data and rationale necessary for total ship conceptual design.
  - g. Perform total-ship Concept (design) Exploration(s) and Concept (design) Development(s) alternatives.
  - h. Present Concept design alternatives "g, above," to CNO/CNM for decision.
  - i. Upon OPNAV and OSD approval, commence Concept (design) Development and assign ship to SHAPM.

ADVANTAGES

- Flag interface with OPNAV.
- Central CNM contact and coordination.
- Permits CNM to assume authority.
- Reduces staffing problems.

DISADVANTAGES

- Possible drift into Alternative I.
- Requires staffing by limited personnel resources.
- Increases lack of continuity in transfer to SHAPM.
- Authority at this level without adequate staffing may constitute "layering."
- Possible arbitrary SDE decision.
- Staffing may not be with best qualified.
- Difficult coordination because of requirements for broad tasking in SYSCOMS.

5.4. Recommended Alternative

Alternative 2 - The Ship Design Executive (SDE) located in MAT-0X with skeleton staff.

Scope and Responsibilities - The SDE would report to CNM in a line capacity at MAT-0X. (PM status is ruled out as being of a somewhat lower authority because of the large number of PM(s)), Funds, normally RDT&E, would be controlled by the SDE and would be allocated internally for contractor/ laboratory support and/or to Systems Commands for their analytical ship design tasks.

The ship design process would begin with the requirements for a new SCN-funded ship type being generated in OPNAV. The requirement in OPNAV might originate in OP-96 from force level studies in which a specific deficiency of present ship/platform capability is identified. Ship requirements could also originate on the Naval Material Command side when new technology in ship concept or combat systems could point to come significant improvement in capability.

The principal starting point would, however, be the OPNAV mission requirements or mission goals for a new ship class. These would be comparable to the TSOR normally used for initiating development. Included in the transmittal would be adequate RDT&E funds enabling the ship concept design work to be accomplished. Dialogue between the SDE and the OPNAV sponsor would have been established even before the mission requirements are formalized. Through this dialogue, the ship missions may be refined and modified by use of preliminary rough estimates of their impact on ship performance and cost envelopes. Scenarios and threats derived from OPNAV force level studies would be furnished to NAVMAT along with the mission

requirements. The scenarios and threats, being identical to those used in official OPNAV force level studies, would provide necessary continuity to the ship design process.

In the case of a new ship to be designed and built with SCN funds, and upon receipt of mission requirements, constraints, threats and scenarios, and required funding, the SDE organization would examine those requirements to initially scope the ship. He would then assign and fund appropriate tasks to SYSCOMS, PM(s), etc., to accomplish the following:

- Develop ship combat systems alternatives composed of the appropriate candidate subsystems. Define alternatives of total-ship integrated combat suites. Obtain all necessary performance parameters needed in assessing military effectiveness.

- Analyze and rank the relative military effectiveness of each alternative against the given mission, threats and scenarios.

- Develop alternative ship hull and propulsion designs for each combat suite and analyze these designs against OPNAV mission requirements.

- Conduct trade-offs within the overall ship, including combat suite.

- Conduct cost analysis using cost elements and estimates, or appropriate cost estimating relationships necessary.

- Conduct risk assessment in the following areas:

  -- Technical risk in achieving desired capability.

  -- Schedule risk in obtaining the equipment when needed.

  -- Cost risk in obtaining equipment and acquiring ship within cost envelope.

- Develop presentations of complete ship design studies for presentation to and review by:

(1) The CNM and the CNM Shipbuilding Council.

(2) The OPNAV ship sponsor/coordinator.

(3) CEB for final decision on the ship characteristics.

(4) Rework ship design analysis when required by changes made by reviewing authority. The process is iterative and may result in several major changes in ship design. CNM Shipbuilding Council will be included in presentations of these changes.

- Document and publish final ship concept design studies for reference, presentation and review by OSD and the Congressional approval chain.

- Develop performance objectives of total-ship design when characteristics are firm. Also, develop for OPNAV approval a draft of the Tactical Operational Requirements (TOR) needed for programming the combat suite of the ship.

- Turn over the completed package, including ship performance objectives, to the NAVSHIPS selected SHAPM to acquire the new ship.

5.5. Staffing

Because this alternative calls for a skeleton staff, no large reorganization or major staffing problems are envisioned. The proposed permanent staffing and qualifications are as follows:

(1) Ship Design Executive - A Rear Admiral with broad background and experience in the analytical methods used in ship combat systems design, ship construction, and cost analysis.

(2) Deputy - To assist SDE in carrying out his concept design process.

(3) The Combat Systems Analysis Officer - Consisting of the present Director of the Combat Systems Analysis Division (SEA-6512) of

NAVSEASYSCOM. This office, already engaged in identical work, would direct the overall analytical effort for combat suite selection. The present small staff of two officers and three civilian combat system analysts must, however, be augmented with approximately four additional professional analysts plus clerical help to provide the requisite expertise in Command and Communication (C&C), IFF, navigation, etc.

(4) Command Control Communications Officer - One officer and one civilian assistant to provide requisite expertise in areas of communications, navigation and C&C.

(5) Ship design, naval architect officer reassigned from within present NAVSEA staffing. Staff of additional professional assistants would be required.

(6) Cost Analyst - Directed by an officer or civilian. Cost analyst with additional staff of three professionals. The above-listed personnel would constitute the primary permanent staff of SDE.

The new SDE organization would also be charged collaterally to examine new ship concepts and combat system development that could lead to a new military capability. These new approaches would be examined by the present CNM, Combat Systems Advisory Group. This small group of officers, now on location at NSRDC, would be folded into the new SDE (MAT-OX). This group would provide some of the advance development input to identifying new ship concepts. The analytical experience and services of the SDE staff would be available to assist their programs. By placing this organization in the SDE it would be closer to the Navy's official chain for OPNAV-sponsored ship design and development. It would give their output greater visibility in both NMC and OPNAV and could result in the adoption of a proposed concept.

5.6. Funding

Funds to support the tasks establishing the SDE organization would normally be furnished by OPNAV for a specific ship development. Funds would be designated officially as a line item of the RDT&E budget. This is essentially the same funding procedure followed for funding the PF, PHM, SCS, and the SCS ship programs. By the new method, the funding requirements could be more efficiently determined and allocated in NMC with the supervision of the SDE.

To support the work of the former Combat System Advisory Group, a special RDT&E (Cat. II) funding category should be established by MAT-03.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The key to the solution of the problem lies, not only in the performance of analysis of combat suites for ships, but also its timing, for they must be initiated earlier in the planning cycle than heretofore performed. It needs to be performed early enough to influence the acquisition of combat system equipments as well as the selection of ship characteristics. This can mean addressing in preliminary form a ship and its combat system 14 or 15 years before delivery in a careful analytical fashion. At this point, also, synergistic effects of task force composition can be usefully addressed to temper the combat suite performance requirements. The OPNAV studies I have previously identified have laid the basic groundwork to accomplish properly the identification of necessary surface combatant systems. We need now to act on the opportunity which has been provided to do this job properly.

6.2. Recommendations

Most of the Navy surface ship combat system problems are a result of an improper organization that has violated most of the fundamental rules of good bureaucratic management and is now unable to cope with the hard decisions necessitated by a world of resource scarcity and international naval competition. My first and strongest recommendation is that the Naval Material Command organize in accordance with Alternative Approach #2 presented in Section V.

Secondly, I recommend that the methodology proposed in Section IV be integrated into the total ship design program.

APPENDIX 1

GLOSSARY

AAW	Anti-Air Warfare
AEGIS	Advanced Surface Missile System
AD	Auxiliary Destroyer Tender
AS	Auxiliary Submarine Tender
ASMD	Anti-Ship Missile Defense
ASW	Anti-Submarine Warfare
CEB	Chief of Naval Operations Executive Board
CNM	Chief of Naval Material
CNO	Chief of Naval Operations
CSAG	Combat Systems Advisory Group
DEH	Deepwater Escort Hydrofoil
EW	Electronic Warfare
IOC	Initial Operating Capacity
LFS	Amphibious Fire Support Ship
NAVELEX	Naval Electronics Systems Command
NAVMAT	Naval Material Command
NAVORD	Naval Ordnance Systems Command
NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Ship Engineering Center
NAVSHIPS	Naval Ship Systems Command
NMC	Naval Material Command
NSRDC	Naval Ship Research and Development Center
OP	Abbreviated Prefix for OPNAV Codes

OPNAV	Offices and Staff of the Chief of Naval Operations
OT&E	Operational Test and Evaluation
PF	Patrol Frigate
PHM	Patrol Hydrofoil, Guided Missile Ship
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SAIC	Ship Acquisition and Improvement Council
SCB	Ship Characteristics Board
SCS	Sea Control Ship
SDE	Ship Design Executive
SES	Surface Effect Ship
SHAPM	Ship Acquisition Project Manager
SUW	Surface Warfare
TLR	Top Level Requirements
TLS	Top Level Specification
TOR	Tactical Operational Requirements
TSOR	Tentative Specific Operational Requirement

APPENDIX 2

SPECIAL STUDY
DEEPWATER ESCORT HYDROFOIL (DEH)
(STUDY OBJECTIVES AND APPROACH)

A. STUDY OBJECTIVES

The overall objective of this study was to define a modern, militarily effective, yet moderate-cost, hydrofoil weapon system called the Deepwater Escort Hydrofoil (DEH), which could perform the primary mission of being a carrier capable escort plus perform lesser and included missions in high threat environments. The ship defined was to be configured so that it could, in coordination with other naval forces, yield a significantly higher military effectiveness than could present and planned conventional ships. Furthermore, the objective was to arrive at the lowest possible follow-ship cost that would still product an acceptable level of military effectiveness. Recognizing the obvious fact that small displacement ships would cost less than larger ones, the study offered a means of identifying the smallest possible DEH that still met the mission goals. Every effort was to be made to exploit the unique and contributory performance capabilities of a hydrofoil when defining the alternative combat systems. By so doing, the study avoided the pitfall of selecting combat systems which could just as easily be suitable for installation on conventional ships on which equivalent military effectiveness could be expected.

Specific study objectives can be summarized as follows:

a. To develop concepts of operations for DEH-class ships that could exploit the unique benefits of the ship and combat system.

b. To rank alternative multi-mission weapon suites in order of military effectiveness.

c. To design and adjust the ship performance parameters around the specific combat systems and assure installation feasibility.

d. To provide to the decision maker an analytical basis for selection of ship concept design and combat system options where factors of military effectiveness, total ship cost, and risks are provided in a coherent format.

e. To identify, by means of the study, those weapons, sensors, mission suites and overall combat systems that require further development and Navy support if the mission goals of the ship are to be realized.

B. STUDY APPROACH

The study procedures followed for the DEH study were quite similar to those for the Surface Effect Ship Weapons System Confirmation Study (WSCS). This was intentional since the WSCS addressed a new ship concept that, in many respects, was similar to DEH.

The first step was to establish a rough estimate of the DBH/DEH baseline ship. This was available from the Naval Ship Engineering Center (NAVSEC) in a previously prepared 750 Ton DBH Baseline Study. The second step was to conduct preliminary mission analysis with considerable reference to WSCS to determine the useful applications of a DEH having specified ship performance capabilities. Weapons and sensors data were obtained on all possible candidate systems that could perform specific military tasks essential to satisfy the DEH's mission goals. Since planning a DEH to be operational (IOC) in the post-1980 time required selection of modern and militarily effective weapons and sensors, near-term developments and weapon system concepts were evaluated. Systems which could be prototyped by the dates required for installation and test on the lead DEH were also considered if these prototypes were based on state-of-art technology as available in 1973. Systems that were based on future "predicted" state-of-art technology or that were otherwise inadequately or unreliably defined were not evaluated in this study.

Concepts of operations were then devised to capitalize on the unique capabilities of the DEH. The weapons and sensors were next configured into mission suites for the ASW, AAW/SUW, and EW fleet escort missions. The mission goals were carefully considered with their multi-mission tasks interwoven so that all the enemy's targeting, missile, aircraft, and torpedo attack options are nullified, thus combining the ASW role with the EW and AAW roles of the ship. It had been found earlier by preliminary analysis, for DEH as well as SES mission analysis, that a multi-mission escort can be shown to be significantly more cost-effective than its single-mission counterpart. This was true so long as the additional mission suites did not excessively drive the total-ship costs. The concepts of operations and the alternative combat system selected for DEH were evaluated in independent, yet related, effectiveness analysis for each warfare mission. The separate warfare mission analyses for the most part employed common concepts of operations, scenarios and threat models wherever possible, particularly in the case of AAW and EW missions. An overall campaign analysis that combined all warfare missions into one single quantitative comprehensive analysis was not performed. A single campaign model and analysis that would combine all missions would require numerous scenarios to avoid the limitation of a "point solution," which would, of course, be extremely sensitive to the scenario's selected. Thus, the study approach utilized what might be called an integrated concept of operation that very closely interleaved all missions while avoiding the problem of overdependence upon the scenario(s) selected. Risk analysis was also performed for all systems considered.

To establish feasibility of installation of each combat system (suites) on the baseline DEH(s), the Naval Architects at NAVSEC prepared a concept design for each unique combat system. Starting with the 750 Ton baseline, ship concept design was completed for three displacement ship options. These were the nominal 800, 1100, and 1400 Ton DEH. Variations in military payload were designed for these nominal displacement ships. Performance envelopes for each displacement (scheme) of the concept design were computed. Combat system alternatives established some variation in manning. Manning studies were made by the U. S. Naval Personnel Research and Development Laboratory, Washington, D. C., for the overall ship(s). In addition, the

Command Control Communication, Navigation (C^3N) requirements as well as computer integration requirements were analyzed and established for one representative DEH option.

Cost analysis was prepared for all combat systems using standard DOD cost model which included both recurring and non-recurring costs. Since it was understood that a cost-effectiveness design to select among the DEH alternatives should be made using total-ship costs, these costs were estimated for lead and follow ships. Two independent computer cost models for DEH ships were used which were to provide approximations ("Class-F") for the overall DEH costs for lead and follow ships. Cost versus effectiveness analysis was also performed in this study which makes it possible for the decision maker to make a valid selection of an optimum DEH from a complex set of multi-mission suites configured into numerous ship displacement alternatives. By using this procedure, it was possible to select the lowest possible cost ship while observing trade-offs of the various combat systems and ship displacements in arriving at a selection. Finally, as an additional task, this study compared a DEH escort force with a conventional-ship escort force on the basis of cost versus effectiveness.

It was found to be impossible to conduct individual warfare mission analysis such as ASW, SUW, AAW and EW without taking into account the other (and interrelated) warfare missions of the ship. Consequently, the DEH mission analysis and ship concept design by necessity needed to be conducted as a single integrated team effort. The DEH mission analysis and ship concept design study would therefore not be fragmented and "farmed-out" to the various Systems Commands and Project Managers for their independent execution of "cognizant portions." If that approach had been followed, the resultant DEH design might have become a fragmented, incoherent collection of subsystems on a sub-optimized ship platform that would be unlikely to define a new ship with adequate military worth.

The study team was directed by the NAVORD Ship Characteristics and Weapon Systems Analysis Division (ORD-531) and consisted of analysis contractors from Arthur D. Little, Vitro Laboratories, Comptek Research and Auerbach Corporation, as well as NAVSEC. Submission date was December 1973.

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE:

THE SELECTION AND DESIGN OF OPTIMUM COMBAT WEAPON SYSTEMS FOR NAVAL SHIPS

STUDY PROJECT GOALS:

To outline a management approach which could lead to the development of a methodology (analytical approach) for the determination and acquisition of the optimum combat system for Naval ships.

STUDY REPORT ABSTRACT

This study report outlines a new management approach for developing improved analytical methods of determination of and subsequent acquisition of optimum combat systems for Naval ships. The study examines the current practices and procedures used in tactical combat system selection and notes the weaknesses and deficiencies. This study also discusses the weaknesses in the current Navy organization as it relates to the assessment of a ship's military mission effectiveness. An organization is proposed during the ship design period that would facilitate the determination and acquisition of optimum combat systems.

KEY WORDS

MATERIEL   DESIGN AND DEVELOPMENT   SHIPS   COST EFFECTIVENESS   SHIPBUILDING

NAME, RANK, SERVICE	CLASS	DATE
John R. Lastova, Jr., GS-14, DNC	PMC 74-2	13 November 1974